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# How Does the Paper-bill Spread Respond to a Monetary Shock?

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# HOW DOES THE PAPER-BILL SPREAD RESPOND TO A MONETARY SHOCK?

By David Shin

A Senior Honors Thesis

Presented in Partial Fulfillment of the Requirements

To graduate with distinction in Economics for

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## Abstract

The paper-bill spread was extremely volatile during the 2007-2009 crisis, jumping anywhere from 8 to 119 basis points. Since the spread is a proxy for credit market frictions, recent events have brought renewed interest in the relationship between monetary policy and the credit market. Empirical work on this literature has focused on one sample period. Boivin and Giovanni (2003), find that changes in monetary policy conduct reduce the effectiveness of a monetary shock after 1980. Using 1980 as my breakpoint, I seek to answer the following question: how does the paper-bill spread respond to a monetary shock? My VAR impulse responses and variance decompositions indicate that the spread reacts less to a monetary shock after 1980 but remains more persistent. These results suggest that structural changes in the credit market have fundamentally delayed monetary transmission.

## **I. Introduction**

During the 2007-2009 financial crisis, the paper-bill spread jumped anywhere from 8 to 119 basis points. Following this highly volatile period, the US economy nearly slipped into another depression. The spread, the difference between the commercial paper (CP) and Treasury bill rate, measures credit market frictions that may amplify monetary transmission. The crisis has brought renewed attention to the relationship between credit frictions and monetary policy. In order to investigate this relationship, I answer the following question: how does the paper-bill spread respond to a monetary shock?

Empirical work on this topic focuses on one sample period. This work does not consider structural changes in the US economy that may have affected the credit market. Boivin and Giovanni (2003) discover that monetary shocks on output and inflation are less effective after 1980 because monetary policy responds better to inflation expectations and demand shocks. My contribution is to divide my sample period and determine whether the paper-bill spread reacts differently before and after 1980.

Vector Autoregression (VAR) is the most common empirical method to examine monetary policy. Using the federal funds rate as a measure of monetary policy, my VAR determines a monetary shock by accounting for output, consumption, inflation, and commodity inflation as endogenous factors. Impulse response functions and variance decompositions reveal that the reaction of the spread to a monetary shock is lesser in magnitude but remains more persistent after 1980.

Boivin and Giovanni's model assumes complete financial markets. If this is true, the spread would have remained stable during the financial crisis. Credit frictions are an important reality that they neglect. For example, lenders charge a markup to borrowers to compensate for

agency costs (Bernanke and Gertler 1995). The spread increases when lenders must obtain and monitor information about the borrower, who knows more about his credit risks and may accept underpriced loans that do not correctly account for these risks.

I interpret Boivin and Giovanni's result from the standpoint of credit frictions. My impulses responses and variance decompositions suggest that credit frictions react differently to a monetary shock after 1980 and delay its effectiveness. Therefore, changes in the conduct of monetary policy may not be the only reason why monetary transmission changed after 1980. Also, I investigate reasons why this may be true, including growth in the derivatives market. Companies have improved risk management practices that may boost lender confidence and stabilize the credit market.

The rest of my paper is as follows. The literature review summarizes previous works that examine a monetary shock on financial spreads. The methodology section explains the basic assumptions in my VAR and how my work differs from Boivin and Giovanni. The data section looks over trends that suggest credit market frictions have decreased over time. The results section provides a storyline interpretation of my work. In my conclusion, I note that a more specified model is needed to determine how monetary transmission has changed.

## **II. Literature Review**

A few studies analyze monetary shocks on financial spreads. Wingender runs a time series regression on the LIBOR-bill spread. Rather than using interest rate innovations through a VAR, Wingender identifies monetary shocks by using data on Fed futures on dates where an FOMC meeting takes place. He then excludes dates where he believes a monetary shock is endogenously affected by other macroeconomic factors. Wingender finds that a positive shock increases interbank risk premia. One shortcoming is that he subjectively assumes these

shocks are exogenous, when in fact they may be responding endogenously to other economic factors.

Ewing analyzes how a monetary shock affects the default risk premium, defined to be the spread between low grade corporate bonds rated Baa and 10 year Treasury bond rates, spanning over the period January 1981 to September 2000. His VAR uses generalized response functions, which are not sensitive to the ordering of variables. Unlike the popular Cholesky ordering, generalized response functions account for all the contemporaneous effects of variables without any lag. His impulse response reveals that a positive monetary shock actually decreases the premium. However, a generalized response of interest rates treats the interest rate as the first in the Cholesky ordering of a regular VAR and, therefore, may be very unreliable (Kim 2009).

Bernanke et al. (1999) look at the six month paper-bill spread in the empirical part of their paper. Using a standard Cholesky decomposition, they identify a monetary shock by placing the funds rate variable next to last in the Cholesky ordering and assume that the spread does not have any useful information for setting contemporaneous monetary policy. Consistent with their DSGE model, their impulse responses reveal that an expansionary monetary shock decreases the spread. The spread immediately decreases less than 20 basis points and returns to normal levels after four quarters. One drawback is that, since their paper is primarily focused on the theoretical model, they do not mention the number of lags or confidence intervals.

Boivin and Giovanni analyze monetary policy before and after 1980. Their impulse responses reveal that the effectiveness of monetary policy has diminished in the latter period. Using a fully specified model, they argue that the Fed's increased responsiveness to inflation expectations explains almost all of the reduced effect of monetary shocks since 1980. They also run a VAR with output, inflation, commodity inflation, and the federal funds rate in two

quarterly data sets. The first set runs from 1959 Q1-1979 Q3. The second set runs from 1979 Q4-2002 Q2.

One key assumption behind their model is that financial markets are complete. They treat all investment expenditures as if it were non-durable consumption. Since markets are complete, risks are efficiently shared such that each household faces the same intertemporal budget constraint and choose to consume the same amount at each date. The counterfactuals from their estimated model parameters match their actual impulse responses closely.

According to Fender, markets may run efficiently if firms optimize their hedging strategies. Derivatives enable users to transfer risks. Fender's model incorporates the use of interest rate derivatives to protect firms from informational asymmetries. The model assumes firm investment behavior for two periods and generates a financial accelerator. The underlying agency problem creates incentives for firms to hedge. If firms use the optimal hedging strategy, all interest rate effects are reduced to pure cost-of-capital effects, eliminating financial frictions altogether.

My contribution is to run two VARs with 1980 as the breakpoint. My VAR accounts for the endogeneity of monetary policy and is an improvement over Wingender's subjective approach. My impulse responses rely on less critical assumptions than those of Ewing. Similar to Bernanke et al. (1999), I place the spread last in the Cholesky ordering. In addition to Boivin and Giovanni's variables, I include consumption because it plays an important part in their model and monetary policy. Finally, by determining whether the spread has responded differently to a monetary shock, I interpret their results from the standpoint of financial frictions.

### III. Methodology

Some researchers, such as Wingender, attempt to identify a monetary shock by looking for dates in which they believe an exogenous shock took place. However, monetary policy reacts endogenously to economic activity, and variables such as output and inflation may respond to each other. Therefore, VAR is the appropriate tool to analyze monetary policy because it treats every variable endogenously.

Monetary policy encompasses a broad range of actions. According to Wingender, the Fed may exploit the rhetoric of FOMC statements to influence expected future rates and influence risk premiums. The Fed may extend lending facilities and expand on its definition of collateral, as in the case of Bear Stearns and AIG during the 2008 crises. Defining monetary policy this way is not useful for a VAR because these kinds of actions can hardly be quantified.

Researchers use several measures of monetary policy for a VAR. One example is innovations in broad money aggregates. Christiano et al. (1996) argue that shocks to broad money aggregates primarily reflect shocks to money demand while innovations in non-borrowed reserves, a subcategory of money aggregates, involve exogenous shocks in monetary policy.

However, the most persuasive argument I find is by Bernanke and Blinder (1992). They argue that the federal funds rate is the best measure of monetary policy for three reasons. First, out of all the measures, it is the best at forecasting the economy. Second, their estimates of the monetary policy reaction functions suggest that the Fed purposefully manipulates this rate. Third, the funds rate reflects genuine policy changes, not only endogenous responses to the economy. For these reasons, I use the funds rate as my measure of monetary policy.

I define vector  $Y_t = (RGDP_t, CONS_t, CPI_t, COMM_t, FF_t, SPREAD_t)'$  where  $RGDP_t$  is real GDP in United States,  $CONS_t$  is real personal consumption,  $CPI_t$  and  $COMM_t$  stand for



consumer price index and commodity producer price index, respectively, and  $SPREAD_t$  is the three month nonfinancial AA commercial paper rate subtracted by the three month Treasury secondary market rate. Impulse response functions display the effects of shocks on an adjustment path over time. Variance decompositions measure the contribution of one variable to the forecast error variance in other variables.

Mathematically, the structural form of VAR is the following:

$$B_0 Y_t = C_0 + B_1 Y_{t-1} + \dots + B_p Y_{t-p} + \varepsilon_t$$

where  $B_i$  is the  $k \times k$  matrix for  $i = 1, \dots, p$  and  $C_0$  is a  $k \times 1$  vector of constants.  $\varepsilon_t$  is a  $k \times 1$  vector of normally distributed error terms called structural shocks and satisfies the following properties:

1.  $E(\varepsilon_t) = 0$
2.  $E(\varepsilon_t \varepsilon_t') = I$  where  $I$  is the identity matrix
3.  $E(\varepsilon_t \varepsilon_{t-h}') = 0$  where  $h$  is nonzero integer

The reduced form VAR is

$$\begin{aligned} Y_t &= B_0^{-1} C_0 + B_0^{-1} B_1 Y_{t-1} + \dots + B_0^{-1} B_p Y_{t-p} + B_0^{-1} \varepsilon_t \\ &= A_0 + A_1 Y_{t-1} + \dots + A_p Y_{t-p} + e_t \end{aligned}$$

where  $A_0 = B_0^{-1} C_0$ ,  $A_i = B_0^{-1} B_i$  for  $i = 1, \dots, p$ , and  $e_t = B_0^{-1} \varepsilon_t$ .  $e_t$  is the reduced form error term that satisfies the same properties as  $\varepsilon_t$  except the second property, in which case

$$E(e_t e_t') = \Omega \quad \text{where } \Omega \text{ is a contemporaneous covariance matrix, and the non-diagonal elements can be nonzero}$$

With higher  $p$ , the model may over fit the data. The Schwarz criterion selects the appropriate number of lags by introducing a penalty term for the number of parameters in the model. Searching up to three lags, the Schwarz criterion justifies  $p=1$  both before and after 1980.

The moving average (MA) representation of VAR is useful for understanding impulse response analysis. Now that  $p=1$ , I can rewrite the reduced form as

$$Y_t - A_1 Y_{t-1} = A_0 + e_t$$

I define lag operator  $L$  such that  $Y_t = L Y_{t-1}$  so that

$$(I - A_1 L) Y_t = A_0 + e_t$$

If  $(I - A_1 L)$  is invertible, then we can rewrite it as an infinite sum.

$$Y_t - E(Y_t) = (I - A_1 L)^{-1} e_t = \sum_{j=1}^{\infty} A_1^j e_{t-j}$$

The following equation traces out the paths of impulse responses:

$$E(Y_{t+m}) - E(Y_{t+m}|e_t) = A_1^m e_t$$

However,  $e_t = B_0^{-1} \varepsilon_t$ , and  $B_0$  is unknown. I make use of the fact that

$$\Omega = E(e_t e_t') = E(B_0^{-1} \varepsilon_t \varepsilon_t' (B_0^{-1})') = B_0^{-1} B_0^{-1'}$$

$\Omega$  is known, but there are infinitely many ways to decompose  $\Omega$  into two matrices. The most popular method is to use Cholesky decomposition, whereby  $B_0^{-1}$  is assumed to be lower triangular. This method implies my results are very sensitive to the ordering of variables due to different timing assumptions. My ordering is in line with most economists, including Boivin and Giovanni, who place the output variables first, followed by inflation, then the funds rate.

The following is a lower triangular matrix that illustrates Cholesky Decomposition.

$$\begin{bmatrix} c1 & 0 & 0 & 0 & 0 & 0 \\ c2 & c3 & 0 & 0 & 0 & 0 \\ c4 & c5 & c6 & 0 & 0 & 0 \\ c7 & c8 & c9 & c10 & 0 & 0 \\ c11 & c12 & c13 & c14 & c15 & 0 \\ c16 & c17 & c18 & c19 & c20 & c21 \end{bmatrix}$$

Since the funds rate is ordered second to last, monetary policy affects output and inflation variables with a one period lag. Since spread is last in my ordering, it can respond contemporaneously to a monetary shock due to the coefficient  $c_{21}$ . Impulse response analysis consists of a one standard deviation structural shock in  $\varepsilon_t$  and plotting  $A_1^j e_t$  over, in my case, 16 quarters after the shock.

The residual of my VAR regression on funds rate is the exogenous component of monetary policy that cannot be predicted by levels of output and inflation. Because others have identified a monetary policy shock in a similar way, I am confident that my residual is mostly unbiased. The problem with putting more variables in the regression is that they lose degrees of freedom, so it is hard to make any meaningful conclusions this way. Most VARs have no more than six.

I imitate Bernanke et al. (1999) by placing the spread as the very last variable in my Cholesky ordering. The implication is that spread has no marginal contemporaneous effect on monetary policy. One problem with this assumption is that the spread can forecast output by signaling changing default probabilities or corporate cash flows (Friedman and Kuttner 1993). The Fed may consider the spread in setting current policy. However, I believe my identification of monetary policy is valid because economists debate the forecasting property of the spread, which means it probably is not a significant factor in setting current policy. Also, my model does not leave out the impact that the spread may have on monetary policy in subsequent periods.

Runkle criticizes how confidence intervals from normal approximations are too wide so that meaningful conclusions cannot be drawn from them. To calculate confidence intervals, I use Efron's bootstrap technique. Since residuals represent true disturbances, it should not matter in what order the disturbances occur. Bootstrapping reorders the sequencing of estimated residuals

and calculates a separate impulse response for them, holding the original coefficients constant. I use the JMulTi program to repeat this procedure exactly 1000 times. Out of these projected impulse responses, the 95th percentiles are plotted along with the original response.

One drawback with impulse response analysis is that plotted graphs require subjective judgment in comparing the response of variables before and after 1980. Variance decompositions reveal in percentage terms how much variation in each variable's forecast error is due to a monetary shock.

#### **IV. Data Description**

My two sample periods are 1971Q2-1979Q4 and 1980Q1-2011Q4 from the United States. All my data are from the Federal Reserve Economic Database (FRED), except the 3 month CP rate from the IMF International Financial Statistics (IFS). Since the IFS only goes back to 1971, my time series begins there. CPI is seasonally adjusted. Overall, there are 35 observations in the first period and 128 for the second. The FRED only has RGDP on a quarterly frequency, so I convert other data to be quarterly as well by averaging them.

The nonfinancial rather than the financial spread is more relevant for dealing with informational frictions that affect the entire economy. While mostly banks issue financial paper, various industries, from manufacturing to energy, comprise nonfinancial paper. Only large corporations with stable balance sheets issue CP for short-term financing needs, such as paying for inventories. The risk of default on CP is very low compared to other securities. The primary holders of CP are large institutions such as money market mutual funds, funding corporations, and nonprofit organizations (Anderson). Therefore, the spread deals with informational frictions on a large institutional level rather than individuals or small businesses.

I take the logs and de-trend real gross domestic product, real personal consumption expenditures, consumer price index for all urban consumers, and producer price index for all commodities to obtain  $RGDP_t$ ,  $CONS_t$ ,  $CPI_t$ , and  $COMM_t$ , respectively. My method is the Hodrick-Prescott (HP) filter technique, which finds the deviations from a trend in time series. Rather than filter each sample period, I filter the entire 1971-2011 period because there is no reason to believe that the trends have fundamentally changed after an arbitrary cutoff date. Also, my penalty parameter is 1600, which is the amount recommended by Hodrick and Prescott for quarterly data. My filtering technique contrasts that of Boivin and Giovanni, who find deviations of the natural logarithm of quarterly RGDP from a linear trend.

Below is a table of sample means. Because HP filtered data have zero average, I only concern with  $FF_t$  and  $SPREAD_t$ .

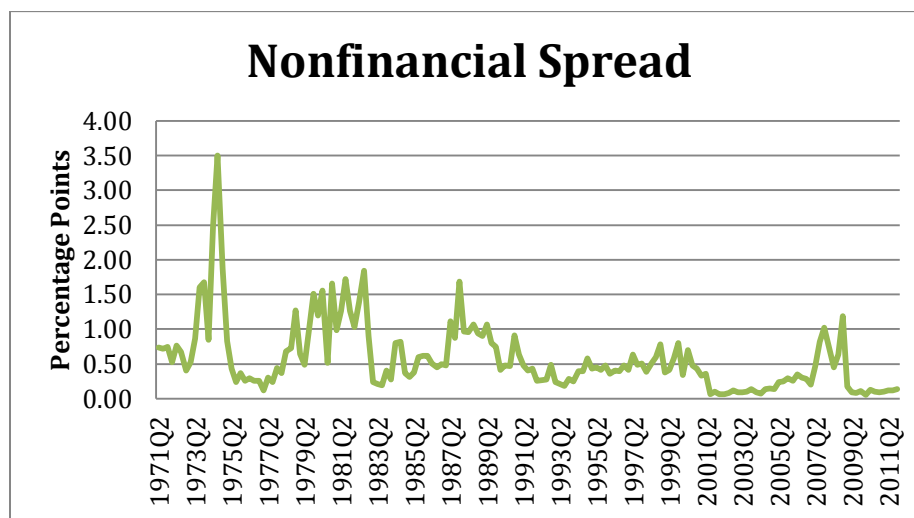
| Period        | $FF_t$ | $SPREAD_t$ |
|---------------|--------|------------|
| 1971Q2-1979Q4 | 7.19   | 0.82       |
| 1980Q1-2011Q4 | 5.65   | 0.51       |

Below is a table of standard deviations.

| Period        | $FF_t$ | $SPREAD_t$ |
|---------------|--------|------------|
| 1971Q2-1979Q4 | 2.63   | 0.71       |
| 1980Q1-2011Q4 | 3.91   | 0.39       |

The spread has a lower mean after 1980 and is less volatile, suggesting that informational frictions have decreased over time. The history of the CP market shows that the spread does not respond as sensitively to economic downturns as before. According to the following graph, the

peak of the spread occurred during the 1973-1974 stock market crash in which the economy was hit by a series of oil price shocks and the collapse of the Bretton Woods system. In 1989 the market oversaw three defaults, with four more followed in 1990 (Anderson). The spread during this time period was nowhere near the level of 1973-1974. During the financial crisis, the spread increased relatively modestly to levels no more than that of 1989-1990. These patterns imply that informational frictions have decreased so that the spread should not be as responsive to monetary shocks as time progresses.

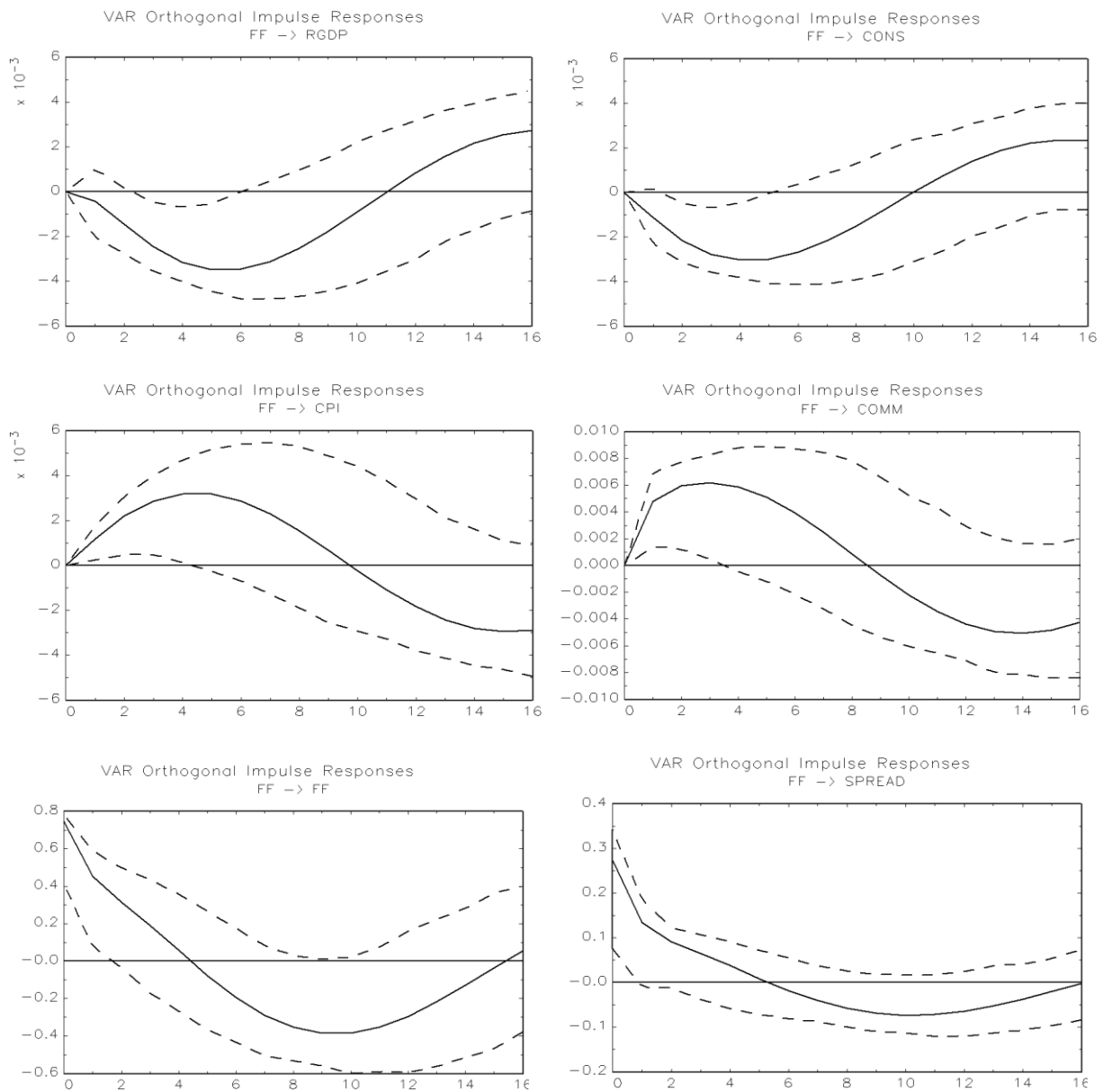


Alternatively, the historic decrease in spread may be due to supply and demand factors. MMMFs may have changed the dynamics of supply and demand factors to lower the long-term equilibrium interest rates of CP. Money Market Mutual Funds (MMMFs) began in 1971 and fundamentally spurred growth in the CP market throughout the 70s and 80s (Anderson). Although CP had existed long before, MMMF shares provided more accessibility to the CP market. Investors and savers found MMMF shares to be a diversified, low risk alternative to bank deposits. The supply of funds increased and lowered the equilibrium interest rate. Also, in the past decade, companies have taken advantage of low rates to issue longer-term securities so the demand for CP has decreased, lowering the spread.

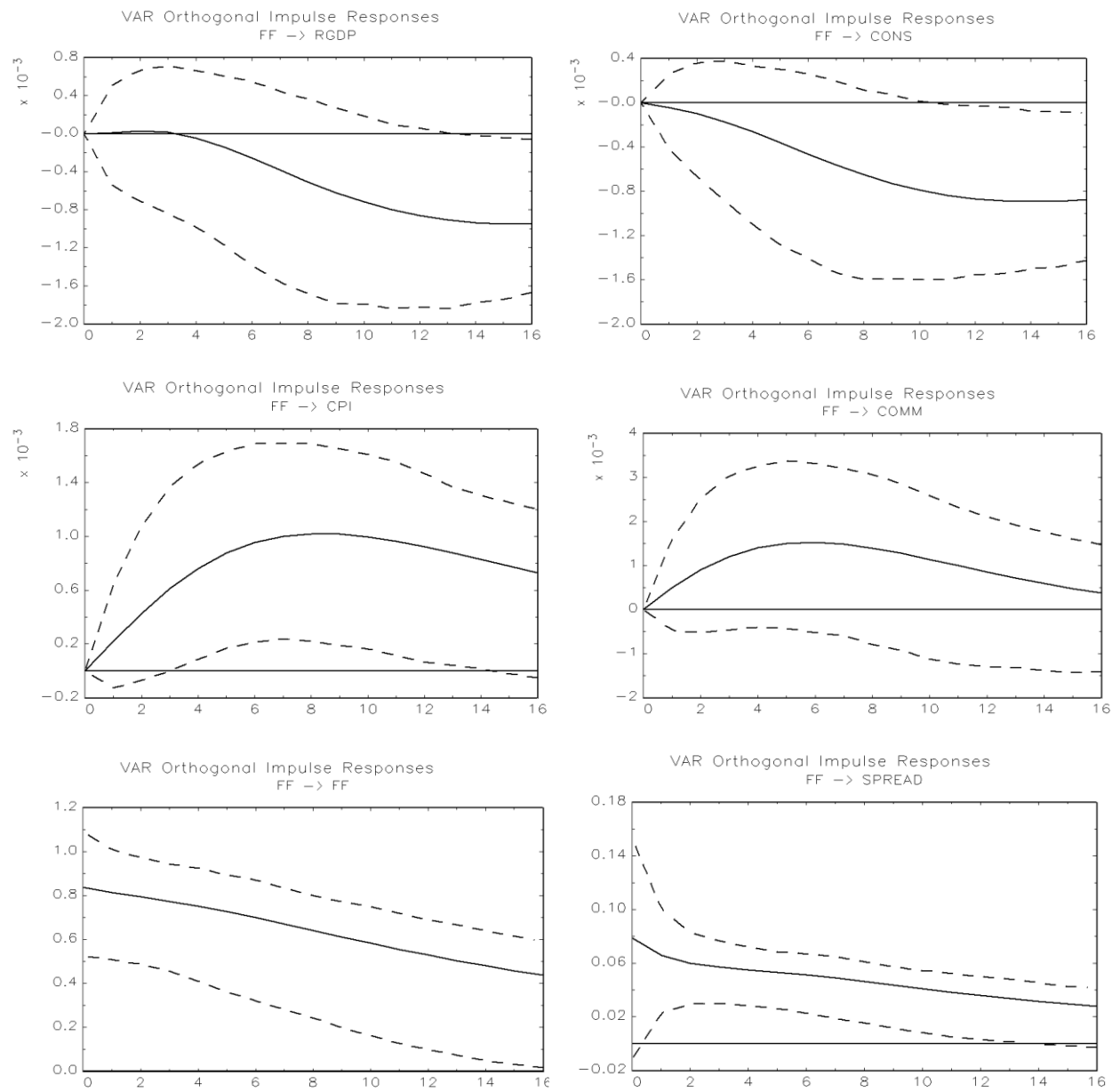
## V. Results

My impulse responses confirm Giovanni and Boivin's finding that monetary shocks are less effective after 1980:

1971Q2-1979Q4



# 1980Q1-2011Q4





Before 1980, RGDP and consumption are more sensitive to a monetary shock. RGDP responds immediately and is statistically significant by the third period. Boivin and Giovanni's RGDP response shows the nadir around four quarters, and so does mine. Consumption responds slightly faster but mirrors RGDP in the timing of its response. The fund rate's response is similar to Boivin and Giovanni's. The spread immediately increases close to 30 basis points but is only significant for about a quarter. Similar to Bernanke et al. (1999), the response crosses zero around the fourth quarter.

While Boivin and Giovanni's inflation response increases for a period and declines, mine has the price puzzle. The price puzzle is a common occurrence in VAR literature and will require more theoretical work to be resolved. The commodity index also shows a price puzzle that is significant for a couple periods.

After 1980, RGDP does not respond for four quarters. It decreases thereafter and eventually becomes significant. This response contrasts sharply with the previous period. Boivin and Giovanni show a faster decline in output, but it is not significant at all. Consumption decreases faster but is still statistically insignificant until a couple years have passed. The funds rate responds by remaining positive for all sixteen periods. Boivin and Giovanni's response has the funds rate starting positive but returning to normal levels after two quarters. The spread immediately increases by eight basis points and is insignificant at first. However, the spread declines very slowly, remaining significantly positive for a couple years.

The following tables list variance decompositions of a monetary shock on another variable. For example, 29.94% of the spread forecast variance is attributed to a monetary shock in the first period for 1971-1979.

### 1971Q2-1979Q4

| Period | RGDP     | CONS     | CPI      | COMM     | FF       | SPREAD   |
|--------|----------|----------|----------|----------|----------|----------|
| 1      | 0        | 0        | 0        | 0        | 67.5535  | 29.94196 |
| 2      | 0.210878 | 2.329464 | 3.345279 | 5.977982 | 52.43388 | 27.68603 |
| 3      | 1.845129 | 6.449748 | 7.578958 | 10.56956 | 40.67949 | 26.07244 |
| 4      | 4.908642 | 10.14039 | 10.76836 | 13.21497 | 31.62479 | 25.02947 |
| 5      | 8.177875 | 12.87449 | 12.58208 | 14.29008 | 24.5284  | 23.92972 |
| 6      | 10.88028 | 14.53923 | 13.10255 | 14.10514 | 19.54824 | 22.60769 |
| 7      | 12.69742 | 15.09868 | 12.56321 | 13.00658 | 16.58932 | 21.27271 |
| 8      | 13.50991 | 14.63983 | 11.30856 | 11.44111 | 15.20475 | 20.19201 |
| 9      | 13.35695 | 13.44015 | 9.742559 | 9.859989 | 14.86058 | 19.50552 |
| 10     | 12.46441 | 11.91912 | 8.23645  | 8.592115 | 15.08362 | 19.20029 |
| 11     | 11.20324 | 10.49003 | 7.048103 | 7.790819 | 15.49293 | 19.16138 |
| 12     | 9.960916 | 9.428199 | 6.295272 | 7.460089 | 15.79885 | 19.23181 |
| 13     | 9.013978 | 8.83407  | 5.978413 | 7.512099 | 15.81277 | 19.26009 |
| 14     | 8.479844 | 8.672796 | 6.023117 | 7.817563 | 15.4677  | 19.13621 |
| 15     | 8.34339  | 8.834075 | 6.318156 | 8.238313 | 14.82392 | 18.81635 |
| 16     | 8.510301 | 9.178953 | 6.741512 | 8.647658 | 14.03487 | 18.32925 |

### 1980Q1-2011Q4

| Period | RGDP     | CONS     | CPI      | COMM     | FF       | SPREAD   |
|--------|----------|----------|----------|----------|----------|----------|
| 1      | 0        | 0        | 0        | 0        | 87.10322 | 8.799302 |
| 2      | 0.004189 | 0.007218 | 0.18602  | 0.083897 | 84.90091 | 12.69249 |
| 3      | 0.008165 | 0.037579 | 0.660586 | 0.28152  | 82.66407 | 16.20378 |
| 4      | 0.007019 | 0.117122 | 1.433241 | 0.575217 | 80.93437 | 19.08743 |
| 5      | 0.012116 | 0.27883  | 2.469777 | 0.929174 | 79.63166 | 21.4256  |
| 6      | 0.049777 | 0.555288 | 3.701022 | 1.301354 | 78.63704 | 23.33826 |
| 7      | 0.152271 | 0.971393 | 5.039052 | 1.654557 | 77.87271 | 24.91218 |
| 8      | 0.348452 | 1.539049 | 6.396097 | 1.963073 | 77.29199 | 26.21055 |
| 9      | 0.657181 | 2.254746 | 7.699808 | 2.214237 | 76.8639  | 27.28517 |
| 10     | 1.084149 | 3.100176 | 8.900982 | 2.406349 | 76.56423 | 28.18065 |
| 11     | 1.621735 | 4.045482 | 9.973821 | 2.545044 | 76.37166 | 28.93468 |
| 12     | 2.251265 | 5.054218 | 10.91143 | 2.639697 | 76.2665  | 29.57795 |
| 13     | 2.94685  | 6.088754 | 11.71964 | 2.700666 | 76.23067 | 30.13447 |
| 14     | 3.679766 | 7.114906 | 12.41134 | 2.737544 | 76.24791 | 30.62245 |
| 15     | 4.422444 | 8.105004 | 13.00224 | 2.758273 | 76.30409 | 31.05548 |
| 16     | 5.151345 | 9.039215 | 13.50816 | 2.768891 | 76.38727 | 31.4436  |

Due to my Cholesky ordering, a monetary shock only affects spread in the first period. For all other variables, the percentages in the first period are zero due to my one period lag assumption.

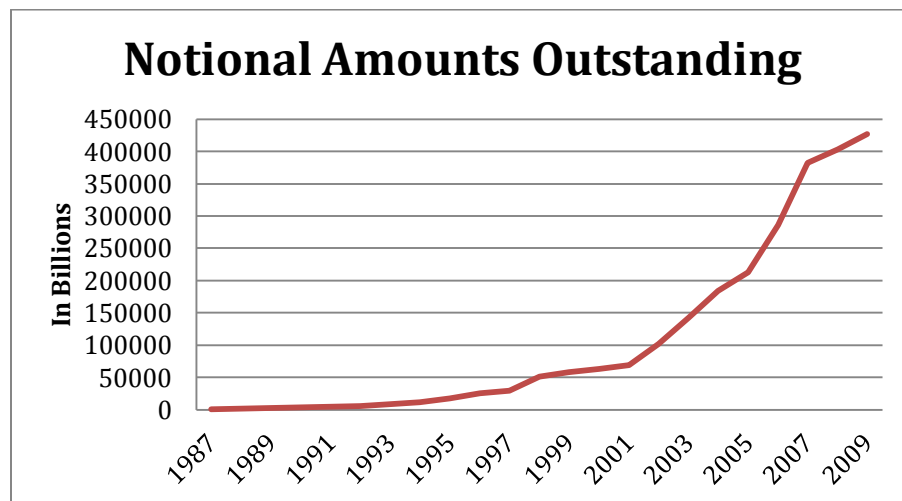
The numbers reveal that monetary shocks are less effective in the latter period. However, the fact that a monetary shock accounts for less than one percent of the forecast variance of RGDP and consumption for at least seven quarters is somewhat troubling. These numbers seem quite low. On a positive note, monetary policy does have a stronger effect on these variables after two years.

Taken together, my impulse responses and variance decompositions reveal a fascinating story. Before 1980, a monetary shock accounts for a greater proportion in the forecast variances of RGDP, consumption, inflation, commodity inflation, and spread for the first year. The impulse responses show that credit frictions flow into the economy and put an immediate halt on growth in output and consumption. With the spread, the percentage of its forecast variance due to a monetary shock decreases steadily before 1980. The impulse response of the spread shows that frictions have died out by the time the economy is in recession. The effectiveness of monetary policy is short-term.

After 1980, financial frictions behave much differently. At first, monetary tightening has no effect on economic output and the credit market. However, credit conditions remain adverse and discourage consumer spending for long periods of time. The percentage of spread's forecast variance due to interest rates increases steadily, and the impulse response remains significantly positive. After a couple of years, businesses cut output as demand falls. The effectiveness of monetary policy is long-term.

Overall, my impulse responses and forecast variances confirm Boivin and Giovanni's result that monetary shocks are less effective post-1980. But the story is more complex. Structural changes in the credit market may have delayed the effectiveness of monetary policy. Why have frictions responded so differently?

One explanation is the growth in derivative markets over the past few decades. Derivatives allow companies to manage cash flows by hedging against economic downturns and interest rate fluctuations. 1973 marked the beginning of the Chicago Board Options Exchange and the Black-Scholes option pricing model. Swaps and other OTC derivatives began to arise in the 1980s (Greenberger). Below is a graph of notional amount outstanding for total interest rate swaps, interest rate options, and cross-currency swaps from the International Swaps and Derivatives Association market survey.



The derivatives market for interest rates has grown rapidly and is now a fundamental part of our economy. Fender's model helps explain why the spread has not responded as significantly in the latter period. Because firms are well hedged, their future cash flows are more certain, and investors are willing to lend more. The costs of monitoring the firm's cash flows have decreased. The steadily declining response of the spread in post-1980 comes from improved risk

management practices in which derivatives cushion the impact of adverse conditions. Without derivatives, firms bear the full brunt of the magnitude of informational frictions in the first few quarters.

From this standpoint, output and inflation respond less to a monetary shock because there are not enough frictions in the economy to propagate interest rate effects. Lack of hedging and undeveloped risk management practices make economic activity more susceptible to monetary shocks before 1980. Derivatives help companies disperse losses from interest rate fluctuations across several periods. This may be why the response is small but positively significant for many periods in the second sample.

Conceivably, improved monetary policy conduct may also reduce frictions and sensitivity of the spread. Stabilization of output promotes certainty of future cash flows and encourages lenders not to waste resources to acquire more information on borrowers. This would explain how a monetary shock affects the spread less after 1980. But I find no obvious reason why monetary policy causes the spread to remain positive for so long in the second sample and die off quickly in the first sample. Monetary policy may explain the magnitude of the responses, but it does not intuitively explain the different path of impulse responses. For this, a more fully specified model is needed.

## **VI. Conclusion**

I answer the question, “How does the paper-bill spread respond to a monetary shock?” Before 1980, the spread responds very strongly but returns to normal levels after a few quarters. After 1980, the spread increases by a much smaller magnitude but does not return back to normal levels for a few years.

Some problems question the validity of my findings. For example, my first sample period is one decade, and my second period spans three decades. My conclusions on the first period are, therefore, not as strong. Also, the price puzzle appears in both sets of impulse responses.

Although this is a common occurrence in VAR literature, increasing inflation after a monetary contraction may be hard to reconcile with theory. Third, forecast variances for output and consumption seem too low for several quarters after a monetary shock in the post-1980 era.

However, Boivin and Giovanni's work confirm my results that monetary policy has become less effective in recent decades. Despite a few minor differences, my impulse responses mimic theirs. Since monetary shocks affect other variables the way it should, I am confident in my conclusions on the spread.

The growth in derivative markets may change the behavior of the credit market. According to Fender's model, optimal hedging strategies reduce monetary shocks to pure cost-of-capital effects. The one shortcoming is that this model does not explain why frictions delay monetary transmission. The policy implication is that the Fed must time their decisions earlier to stabilize output.

Another reason may be that improved monetary policy decreases frictions by stabilizing output and inflation. If this is the case, the Fed should not waver from its policies to continue promoting market efficiency. If the Fed changes rates drastically, it can amplify these frictions and exacerbate economic swings.

The policy that the Fed should take depends a great deal on the exact relationship between credit frictions and monetary transmission. Unfortunately, because VAR is largely an atheoretical model, it cannot formally extract this relationship. The next step is to incorporate market frictions in a more specified theoretical model and perform counterfactual experiments on

these impulse responses. For future empirical work, other proxies for market frictions, such as the prime-bill spread, may be useful to confirm my results. The financial paper-bill spread may draw new insight into how frictions uniquely affect the banking system. Other measures of inflation, such as GDP deflator, may overcome the price puzzle. Despite my progress, what exactly caused the spread to be so volatile during the 2007-2009 crisis remains a mystery.

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